OPEN ACCESS International Journal of Dairy Science
ISSN 1811-9743
DOI: 10.3923/ijds.2017.

Research Article
Nutraceutical Food Based on Cereal and Probiotic Fermented Milk

[1]Safaa Abdel-Aleem El-Aidie, [2]Samia Mahmoud El-Dieb, [3]Mohammed El-Nawawy, [1]Essa Emara and [4]Hassan Sobhy

[1]Department of Dairy Technology, Animal Production Research Institute, Agricultural Research Centre, Dokki, Giza, Egypt
[2]Faculty of Agriculture, Cairo University, Giza, Egypt
[3]Faculty of Agriculture, Ain-Shams University, Cairo, Egypt
[4]Institute of African Research and Studies, Cairo University, Giza, Egypt

Abstract
Background and Objective: Cereals have always been considered principal sources of energy, carbohydrates, protein, fiber and some micronutrients in diets. Also, fermented milk products have been considered a highly nutritious food containing significant concentration of protein, fat, minerals and micronutrients. So, the production of a food product that combines the benefits of cereals and fermented milk is useful for feeding many categories. The aim of this study was to produce a nutraceutical food based on cereal and fermented milk for children and adults. **Materials and Methods:** Five cereal-based fermented milk products were manufactured from cow fermented milk by yoghurt starter and *Lactobacillus helveticus* (*L. helveticus*) and some cereals of wheat (PW), oats (PO), sorghum (PS), naked barley (PBI) or barley (PBII). These products were stored at room temperature for 120 days. Titratable acidity (TA %), moisture, fat, total nitrogen, ash, fiber, mineral, amino acid contents and total lactic acid bacterial counts (TLAB), in all samples were determined during storage by using 2 way ANOVA and SPSS. **Results:** The titratable acidity was higher in PO when fresh than other products and it decreased in all products with the storage period progressed. The moisture content was different between all products and it decreased during the storage period. Fat/DM and TP/DM in fresh PO was the highest and it increased during storage. Fresh PBII had the highest fibers, calcium, Mg and Zinc contents. All essential amino acids were detected in all products, contrary, tryptophan was not detected. TLAB were the lowest in fresh BPI, while it decreased in all products dering storage. Total lactic acid bacterial count decreased during storage in all products. PO and PBII gained the highest acceptability scores. **Conclusion:** This study concluded that successful production of nutraceutical food based on cereal and fermented milk. The KO and KBII products gained the highest acceptability scores followed by PBI, PS and PW. Thus recommended to produce a highly nutraceutical product from fermented cow milk using a yoghurt starter and *L. helveticus* mixture and oat or barely.

Key words: Fermented milk, yoghurt starter, cereal, Lactic acid bacterial count, *Lactobacillus helveticus*

Citation: Safaa Abdel-Aleem El-Aidie, Samia Mahmoud El-Dieb, Mohammed El-Nawawy, Essa Emara and Hassan Sobhy, 2017. Nutraceutical food based on cereal and probiotic fermented milk. Int. J. Dairy Sci., CC: CC-CC.

Corresponding Author: Safaa Abdel-Aleem El-Aidie, Department of Dairy Technology, Animal Production Research Institute, Agricultural Research Centre, Dokki, Giza, Egypt Tel: +60147414801

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Consumers' demands for healthier foods have become important and increased, where the industry is directing to develop new products towards the area of nutraceutical foods[1].

The term ‘nutraceutical’, combines between ‘nutrition’ and ‘pharmaceutical agents’ introduced in 1989, which defined as ‘any substance that is a food or a part of a food and provides medical or health benefits, including the prevention and treatment of disease[2,3]. Nutraceutical covers a wide range of different products, that naturally occurring, which led to influence human health positively and also a variety of functional foods, fortified foods and dietary supplements[4-6]. Nutraceutical compounds include the list of antioxidants, vitamins, prebiotics, probiotics, fatty acids and bioactive peptides and scientific evidence that supports their therapeutic potential and the health benefits associated with them are constantly increasing[7-9]. Although, nutraceuticals recognized that their addition to food products aids in preventing the risk of disease, especially chronic diseases and inflammation and improve public health, their pathways when performing physiological functions in the human body have not yet been fully elucidated[7,8,10]. Nutraceuticals contribute to high rates of polypharmacy, particularly among older people with multiple diseases, which enhance overall health and wellness, to fill dietary nutrient gaps, to stimulate immune health and to boost energy, bone and heart health[11,12].

Cereals are considered one of the most important sources of food[13], which have contributed to human nutrition for millions of years[14]. The major cereal crops grown in worldwide are wheat (*Triticum* spp.), rice (*Oryza* spp.), maize/corn (*Zea mays* L.), barley (*Hordeum vulgare* L.) and other cereals include millet, sorghum, rye, oat and triticale[14]. Oats and barley are major sources of beta glucan, recognized as a major functional component of cereal fiber. Research has confirmed that the effect of the hypocholesterolaemic from this compound leads to 20-30% reduction of LDL-cholesterol and thus reduces the risk of cardiovascular disease[15-18].

Fermented foods based on milk-cereal mixtures are an important part of the diets of many people in many parts of the world and are known from ancient times in the middle East, Asia, Africa and some parts of Europe, because of their nutrition, health and organoleptic characteristics[19]. Cereal fermentation by LAB is accompanied by many advantages such as general improvement in shelf life, texture, taste and smell, nutritional value and digestion of protein and significantly reduces the anti-nutrients content of cereal products and finally enhances organoleptic qualities. Where, it contributes to the degradation of phytic acid which bind divalent cations (zinc, iron and calcium) and decreasing their bioavailability. Degradation of phytic acid is caused by phytases, which are present in cereals and they are produced by lactic acid bacteria[20-24].

Therefore, this study was conducted for the possibility of preparing nutraceutical fermented milk products based on cereals using probiotic bacteria and studying the chemical, microbial and sensory properties of these products.

MATERIALS AND METHODS

Materials: Milk was obtained from the herd of the Faculty of Agriculture, Cairo University. Giza, Egypt. *Streptococcus thermophilus* and *Lactobacillus delbruekii subsp. bulgaricus* (yoghurt starter cultures) and *Lactobacillus helveticus* were obtained from Chr. Hansens Laboratories, Copenhagen, Denmark.

Cereals of wheat (Gemmeza 11), naked barley (Giza 130) and barley (Giza 126), oats and sorghum were purchased from the Field Crops Researh Institue (FCRI), Agriculture Research Center, Egypt.

Violet red bile glucose agar, oxytetracycline-glucose-yeast extract agar, plate count agar and MRS agar media were purchased from Oxoid Ltd., Basingstoke and Hampshire, England.

Spice mixture contained: All spice, cumin, coriander and Safflower at ratio 1:2:2:1 and they were purchased from local markets.

This study was carried out in Animal Production Research Institute that follows Agricultural Research Center, Giza, Egypt, on March, 2015. Probability was used to decide the level of significance, 0.01. Manufacturing carried out in Laboratories of the Department of Dairy Technology at the Institute of animal production research.

Methods

Experimental procedure: The fresh cow milk, heated at 85°C for 10 min and cooled to 45°C. Milk was divided into two equal parts. The first part of milk inoculated with the yoghurt starter culture. The second part inoculated with the *Lactobacillus helveticus* at ratio 3% (w/w) and incubated at 42°C. Once curdling was complete, fermented milk was kept at 4°C until the second day. The two parts of fermented milk were mixed together and concentrate it (1.653% acidity, 5.33% fat, 8.64% TP, 1.63% ash, 4.32% lactose and 19.93% TS).

Cereals of wheat, oats, sorghum, naked barley and barley were cleaned of stalks, dirt and weed seeds. The grains for each socked with water in large cooking pans for 1 h at room temperature. Each cereal was heated until boiling for 30 min. The cooked cereals are spread on aluminum foil and dried in oven at 50°C for 2 days, then rubbed by a machine. Each coarse granule is mixed with concentrated fermented milk at a level of 1:2 (w/w) respectively, then keeping 1 day at room temperature for fermentation. This mixture moistened with salted whey (1% salt) and added the spices (0.5%). Afterwards, the mixture is formed into small balls, placed on plates and dried in oven at 50°C for 48 h. The products packed in plastic bags and stored at room temperature for 120 days. Titratable acidity, moisture, fat, total protein, ash as well as the organoleptic properties was determined when fresh and after 15, 30, 60, 90 and 120 days, while fiber, minerals and amino acids were analyzed when fresh.

Methods of analysis

Chemical composition: Titratable acidity, moisture, fat, total nitrogen, ash and fiber contents were determined according to the method described by AOAC[25]. The protein contents in cereal- based fermented milk products were calculated according to Tamime *et al*.[26].

The content of calcium, sodium, potassium and magnesium, zinc, iron and phosphorus were determined according to the methods of Jansen and Helbing[27], Trinder[28], Sunderman[29], Grinder and Heth[30] and Teitz[31], Hayakawa and Jap[32] Dreux[33] and Fiske and Subbarow[34] Goodwin[35], respectively. Amino acid hydrolysis were carried out according to the method of Block *et al*.[36].

Microbiological analysis: Total lactic acid bacterial counts (TLAB) were estimated using MRS agar medium. The plates were incubated at 37°C for 48 h as recommended by the American Public Health Association (APHA)[37]. The count of aerobic spore forming bacteria (SC) was determined as described by Luck and Gavron[38]. The plates were incubated at 32°C for 48 h. Coliform bacteria (CC) were enumerated using violet red bile glucose agar (VRBA) medium. The plates were incubated at 37°C for 24 h as reported by Wehr *et al*.[39]. Molds and yeasts (M&Y) were enumerated using oxytetracycline-glucose-yeast extract agar (OGYE Agar) medium according to IDF[40]. The plates were aerobically incubated at 25°C for 5 days.

Sensory evaluation: Cereal-based fermented milk product samples were judged by the staff members of the Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture. The samples were prepared by mixing 20 g of product after ground with 250 mL chicken soup and boiling for 10 min with stirring. The cooked samples were served to the panelist at 50°C[41]. The scoring system for sensory attributes was as follows: Acceptability, taste, odor, sourness, appearance, colour and texture scored out of 10 points, as mentioned by Hassan and Hussein[42].

Statistical analysis: The experiments were repeated in the duplicates and each analysis was repeated in triplicates and the average of results was recorded. The statistical analysis was carried out using the IBM statistical package (SPSS21). The overall effects of treatments were analyzed are conducting a two-way (ANOVA) statistically different groups were determined by Duncan test ($p\leq 0.01$)[43].

RESULTS AND DISCUSSION

Chemical composition of cereal-based fermented milk products: In Table 1, the titratable acidity (TA) was significantly higher in product prepared with oat when fresh than all treatments. The products are ranked descendingly according to TA as follows, the product with oat (PO), the product with sorghum (PS), the product with wheat (PW), the product with barley (PBII) and finally the product with naked barley (PBI). These results may be due to all used cereals improved the acidification rate of cultures and the cereal components can be used as fermentation substrates for probiotic organisms. These results are consistent with Zare *et al*.[44] and Salameh *et al*.[19]. On the other side, results from the same Table 1 showed that, TA was slightly decreased in all samples as the storage period progressed. The TA decreased significantly at 30 days of storage and the reduction continued until the end of storage period in all samples. This reduction may be attributed to the decrease of moisture and increase of salt contents in samples that would inhibit the growth of microorganisms[45].

The moisture content was significantly different between all treatments where PO and PS had lower moisture content than other products (Table 1). The difference in moisture content between all treatments may be attributed to the manual manufacturing condition.

Results also depict a continuous decrease in moisture content of all samples during the progress of storage period to reach the minimum values at the end of storage. The same trend was observed by Abdel-Aal[46]. Moisture decreased significantly at 30 days in all treatments and continued to

Table 1: Chemical composition of cereal-based fermented milk products

		Storage period (days)					
Products	Parameters (%)	0	15	30	60	90	120
PW	Acidity	3.283^{ac}	3.175^{abc}	3.075^{bcc}	2.875^{cdc}	2.775^{dc}	2.750^{ec}
	Moisture	8.589^{ab}	8.543^{ab}	8.296^{bb}	8.036^{bb}	7.758^{cb}	7.513^{cb}
	Fat/DM	14.170^{cdab}	14.234^{cab}	14.259^{bab}	14.278^{abab}	14.306^{aab}	14.333^{aab}
	TP/DM	15.018^{dd}	15.043^{dd}	15.079^{cdd}	15.189^{bcd}	15.276^{bd}	15.437^{ad}
PO	Acidity	3.675^{aa}	3.600^{aba}	3.480^{bca}	3.450^{cda}	3.416^{da}	3.325^{ea}
	Moisture	8.026^{ac}	7.989^{ac}	7.764^{bc}	7.506^{bc}	7.209^{cc}	6.955^{cc}
	Fat/DM	14.583^{cda}	14.642^{ca}	14.662^{ba}	14.695^{aba}	14.711^{aa}	14.745^{aa}
	TP/DM	16.302^{da}	16.366^{da}	16.382^{cda}	16.474^{bca}	16.566^{ba}	16.684^{aa}
PS	Acidity	3.350^{ab}	3.300^{abb}	3.175^{bcb}	3.150^{cdbb}	3.080^{db}	3.000^{eb}
	Moisture	8.245^{ac}	8.215^{ac}	7.967^{bc}	7.684^{bc}	7.365^{cc}	7.119^{cc}
	Fat/DM	13.991^{cdb}	14.051^{cb}	14.084^{bb}	14.100^{abb}	14.123^{ab}	14.160^{ab}
	TP/DM	15.539^{dc}	15.594^{dc}	15.675^{cdc}	15.756^{bcc}	15.830^{bc}	15.888^{ac}
PBI	Acidity	3.100^{ad}	2.925^{abd}	2.850^{bcd}	2.775^{cdd}	2.725^{dd}	2.500^{ed}
	Moisture	8.792^{ab}	8.753^{ab}	8.516^{bb}	8.261^{bb}	7.856^{cb}	7.591^{cb}
	Fat/DM	13.818^{cdb}	13.877^{cb}	13.911^{bb}	13.932^{abb}	13.939^{ab}	13.970^{ab}
	TP/DM	14.585^{df}	14.634^{df}	14.707^{cdf}	14.804^{bcf}	14.844^{bf}	14.920^{af}
PBII	Acidity	3.125^{ad}	3.025^{abd}	2.850^{bcd}	2.800^{cdd}	2.525^{dd}	2.500^{ed}
	Moisture	8.843^{ab}	8.785^{ab}	8.558^{bb}	8.233^{bb}	7.974^{cb}	7.688^{cb}
	Fat/DM	14.192^{cdab}	14.248^{cab}	14.285^{bab}	14.306^{abab}	14.330^{aab}	14.359^{aab}
	TP/DM	15.985^{db}	16.020^{db}	16.038^{cdb}	16.096^{bcb}	16.169^{bb}	16.275^{ab}

PW: Product with wheat, PO: Product with oats, PS: Product with sorghum, PBI: Product with naked barley, PBII: Product with barley. The same capital letters for each row (storage period) are not significantly different ($p>0.05$), The same small letters for each column (treatment) are not significantly different ($p>0.05$)

decrease until the end of storage period. However, there was no significant difference in moisture content at 90 and 120 storage periods.

Table 1 revealed that, fat/DM of PBII and PW products was nearly similar, but that of PO product was the highest. Fat/DM in products was ranked descendingly as follows, PO, PBII, PW, PS and PBI. These results may be due to the oat had a higher fat content than other cereals[47]. Results also illustrated that a slight increase in fat/dry matter content of all samples during the storage period to reach the maximum values at the end of storage. During storage, fat/DM matter increased significantly at 30 days in all samples and continued until the end of storage. The fat/DM was ranged from 13.970-14.745% of all products except product with wheat, where it was 14.333% at the end of storage with the average increase through the storage period of 0.16%.

Total protein/dry matter (TP/DM %) was presented in Table 1. It is worth mentioned that, cereal-based fermented milk products were significantly enriched with protein of all treatments. TP/DM within treatments was significantly different ($p\leq 0.05$), where the fresh PO product achieved the highest content of TP/DM (16.302%), followed by PBII (15.985%), PS (15.539 %), PW (15.018%) and PBI (14.585%). In this respect these results are in agreement with Tamime *et al.*[47]. Storage period for 120 days led to a significant increase in TP/DM for all samples. The average of these increases ranged from 0.29-0.4% during storage period.

Figure 1 illustrated the changes in fiber content of fresh cereal-based fermented milk products as affected by the type of use cereals types. Results showed that PBII and PO products had the highest fiber content as it was 6.8 and 6.25%, respectively. However, PBI and PS products contained 5.66 and 5.18% of fibers, respectively. PW contained the lowest level of fiber as it was 3.06%.

The concentration of minerals in all samples when fresh are shown in Table 2. All cereal-based fermented milk products had higher Fe and P content than PW. PO, PS, PBI and PBII products were higher in Ca and Mg while, PO, PBI and PBII products were higher in Zn than other treatments. Na was fluctuating between all treatments.

The free amino acids were determined in all cereal-based fermented milk product samples when fresh and presented in Table 3. It is evident that, all products were containing 16 free amino acids, including all the essential ones except Methionine, which was not detected in PS product only. Tryptophan was not detected in all samples, as a result of acid hydrolysis which destroyed it. This finding is agreement with Damir *et al.*[48] and Tamime *et al.*[49].

Microbiological analysis of cereal-based fermented milk products: Regarding the coliform counts, all samples were free while mold and yeast counts were less than

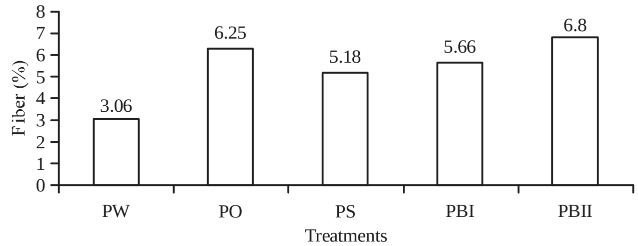

Fig. 1: Fiber content of fresh cereal-based fermented milk products

PW: Product with wheat, PO: Product with oats, PS: Product with sorghum PBI: Product with naked barley, PBII: Product with barley

Table 2: Minerals content of fresh cereal-based fermented milk products

	Minerals (mg/100 g)						
Products	Calcium (Ca)	Phosphorus (P)	Magnesium (Mg)	Iron (Fe)	Zinc (Zn)	Sodium (Na)	Potassium (K)
PW	148	158.4	124.6	2.520	1.635	892.7	204.48
PO	152	163.1	123.5	3.00	1.831	505.7	226.77
PS	141	159.4	125.3	2.941	1.242	734.8	170.83
PBI	133	157.0	121.1	2.879	1.700	886.2	191.19
PBII	168	164.9	128.0	3.037	1.962	775.2	220.12

PW: Product with wheat, PO: Product with oats, PS: Product with sorghum, PBI: Product with naked barley, PBII: Product with barley

Table 3: Amino acids content of fresh cereal-based fermented milk products

	Products				
Amino acids mg/g N	PW	PO	PS	PB I	PB II
Aspartic acid	331.69	306.78	142.74	364.95	379.02
Threonine	133.86	123.81	81.86	156.80	162.85
Serine	379.59	351.08	225.11	321.78	334.18
Glutamic acid	1077.62	996.69	551.50	1070	1112.25
Proline	376.98	348.67	771.97	393.19	408.35
Glysine	106.67	98.66	26.80	93.37	96.97
Alanine	187.42	173.34	78.39	182.87	189.92
Valine	175.07	161.93	52.20	180.94	187.91
Methionine	14.07	13.02	0.000	10.07	10.46
Isoleucine	139.17	128.72	41.73	144.17	149.73
Leucine	299.39	276.91	126.98	317.35	329.58
Tyrosine	50.78	46.96	26.83	49.73	51.64
Phenylalanine	145.38	134.46	24.16	132.84	137.96
Histidine	82.44	76.25	28.71	86.90	90.25
Lysine	165.99	153.53	93.41	186.34	193.53
Arginine	104.30	96.46	20.44	92.03	95.58

PW: Product with wheat, PO: Product with oats, PS: Product with sorghum, PBI: Product with naked barley, PBII: Product with barley

10 $\log_{10}$ CFU mL^{-1} during storage at room temperature for 120 days. Also, the spore forming load of all the experimental products was low.

Table 4, the total lactic acid bacterial counts (TLAB) in fresh PW, PO, PS and PBII were the highest while PBI had the lowest of TLAB. During storage, TLAB decreased significantly after 30 days of storage in all treatments. However, there was no significant difference of TLAB in all treatments at 60 day of storage comparing with at 30 days. However, TLAB decreased significantly at 90 days and continued to non-significantly decreased by the end of storage period. This finding is in agreement with Tamime *et al.*[50], who observed that a significant reduction in the total viable count in Kishks made with yoghurt by the end of the 12 month storage period.

Sensory evaluation of cereal-based fermented milk products: Data presented in Table 5 summarized the sensory evaluation of cereal-based fermented milk products during storage at room temperature for 120 days. All products were higher in the acceptability and PO and PBII gained the highest acceptability scores, then PBI, PS and PW during the storage period. Taste, odour, sourness and appearance of all products

Table 4: Total lactic acid bacterial counts ($\log_{10}$ CFU mL^{-1}) of cereal-based fermented milk products during storage at room temperature

	Storage Period (days)					
Products	0	15	30	60	90	120
PW	7.205^{aa}	7.060^{aa}	6.755^{ba}	6.583^{ba}	6.453^{ca}	6.387^{ca}
PO	6.979^{aa}	6.753^{aa}	6.541^{ba}	6.485^{ba}	6.299^{ca}	6.161^{ca}
PS	6.799^{aa}	6.628^{aa}	6.507^{ba}	6.377^{ba}	6.183^{ca}	6.042^{ca}
PBI	6.335^{ab}	6.181^{ab}	5.800^{bb}	5.772^{bb}	5.596^{cb}	5.190^{cc}
PBII	6.586^{aab}	6.463^{aab}	6.193^{bab}	5.946^{bab}	5.844^{cab}	5.753^{cbc}

PW: Product with wheat, PO: Product with oats, PS: Product with sorghum, PBI: Product with naked barley, PBII: Product with barely, The same capital letters for each row (storage period) are not significantly different (p>0.05), The same small letters for each column (treatment) are not significantly different (p>0.05)

Table 5: Sensory properties of cereal-based fermented milk products during storage

Products	Storage period (days)	Sensory evaluation scores Acceptability (10)	Taste (10)	Odour (10)	Sourness (10)	Appearance (10)	Colour (10)	Texture (10)	Total (70)
PW	Fresh	9.28	9.14	9.57	9.57	9.85	9.71	9.92	67.04
	30	9.81	8.87	9	8.75	9.87	9.12	9.62	65.04
	60	9.5	8.87	8.62	8.62	9.25	9.12	9.25	63.23
	90	8.6	8.2	7.7	8.1	9	8.5	8.6	58.7
	120	7.37	7.50	7.91	7.17	8.08	7.83	7.16	53.02
PO	Fresh	9.85	9.28	9.42	9.71	9.85	10	10	68.11
	30	9.75	9.37	9.5	8.87	9.87	9.5	10	66.86
	60	9.62	9.12	8.75	8.75	9.75	9.5	9.87	65.36
	90	8.9	8.3	8	8.2	9	8.8	9.3	60.5
	120	8.54	8.58	8.33	8.17	8.75	8.96	8.42	59.75
PS	Fresh	8.28	8.7	9.28	8.28	9.42	9.14	7.57	60.67
	30	8.18	8.37	8.18	8.25	9.12	8.62	8.12	58.84
	60	7.18	7.25	7.62	7.56	8.37	7.62	6.62	52.22
	90	7.4	7.4	6.9	6.9	8.7	7.5	6.8	44.7
	120	7.50	7.54	7.83	7.87	8.16	7.66	7.00	53.56
PBI	Fresh	9	9.1	9.42	9.28	9.43	9.14	8.85	64.22
	30	9.37	9.12	9.12	8.87	9.87	9.12	9.62	65.09
	60	9.0	9.0	8.93	8.37	9.62	9.0	8.87	62.79
	90	8.0	8.0	7.8	7.9	9.0	8.4	8.4	57.5
	120	7.75	7.58	8.00	7.75	8.33	8.08	8.46	55.95
PBII	Fresh	9.28	9.14	9.28	9.14	9.57	9.0	8.85	64.26
	30	9.75	9.12	9.37	9.0	9.75	8.75	9.87	56.86
	60	9.5	9.25	9.0	8.62	9.75	9.0	9.75	64.87
	90	7.7	8.2	8.0	8.0	8.9	8.5	8.8	58.1
	120	8.83	8.50	8.66	8.58	8.42	8.50	8.88	60.37

PW: Product with wheat, PO: Product with oats, PS: Product with sorghum, PBI: Product with naked barley, PBII: Product with barely

had almost similar scores. PO product attained higher score for colour followed closely by PBII, PBI (8.08), PW, finally PS. Among the products, scores of texture in PO, PBII and PBI products were significantly higher than scores of PS and PW. These findings coincide with Tamime *et al.*[51], who found that the products based on oats and barley were more viscous, sticky and slimy and less grainy.

The study will help in providing nutraceutical products with low cost to help people in East African countries. The study was limited to the above mentioned available cereals, for future research it is recommended to use other cereals in East African countries such as maize and millet.

CONCLUSION

Regarding the obtained results, it can be concluded that we can use some cereals types such as wheat, oats, sorghum, naked barley and barley with probiotic bacteria to prepared nutraceutical fermented cereal products. Nutraceutical fermented cereal products considered dietary potential as a source of fibers, minerals (Fe, Ca, Zn and Mn) and amino acids. In particular, products based on oat and barely was a good dietary source of β-glucan, fibers and also have acceptable properties. It is therefore necessary to encourage PO, PBII and PBI production and promote its consumption by people for its good nutritive value furthermore its taste, especially oat, barley product (PO, PBII) had a good dietary source of β-glucan, fibers, minerals (Fe and Mn) and amino acids.

SIGNIFICANCE STATEMENTS

This study discovers the importance of using probiotic bacteria and β-glucan (to the best of researchers' knowledge, no researchers used such additives in previous studies) in the production of nutritive food products that combination of cereal and fermented milk. Mixing milk and cereals, with the addition of probiotic bacteria and β-glucan will improve nutrient value, extend shelf life and decrease the production cost for the end products. This study will help the researcher to identify the critical area for the possibility of producing a high-value products targeted at poor countries such as East African countries. Thus, a new theory of these nutritive product combinations and possibly other combinations, may be arrived at.

ACKNOWLEDGMENTS

This study was supported by the Egyptian Ministry of Agriculture and Animal Production Research Institute. The authors would like to thank Dr Sandeep Poddar, Research Director Lincoln University College for his support and to facilitate for performing the research proofreading.

REFERENCES

1. Ramos, O.L., R.N. Pereira, A. Martins, R. Rodrigues and C. Fucinos *et al*., 2017. Design of whey protein nanostructures for incorporation and release of nutraceutical compounds in food. Crit. Rev. Food Sci. Nutr., 57: 1377-1393.
2. Wang, J., S. Guleria, M.A. Koffas and Y. Yan, 2016. Microbial production of value-added nutraceuticals. Curr. Opin. Biotechnol., 37: 97-104.
3. Aronson, J.K., 2017. Defining 'nutraceuticals': Neither nutritious nor pharmaceutical. Br. J. Clin. Pharmacol., 83: 8-19.
4. Palthur, M.P., S.S. Palthur and S.K. Chitta, 2010. Nutraceuticals: A conceptual definition. Int. J. Pharm. Pharm. Sci., 2: 19-27.
5. Schmitt, J. and A. Ferro, 2013. Nutraceuticals: Is there good science behind the hype? Br. J. Clin. Pharmacol., 75: 585-587.
6. Drake, P.M., T.H. Szeto, M.J. Paul, A.Y.H. The and J.K.C. Ma, 2017. Recombinant biologic products versus nutraceuticals from plants: A regulatory choice? Br. J. Clin. Pharmacol., 83: 82-87.
7. Cencic, A. and W. Chingwaru, 2010. The role of functional foods, nutraceuticals and food supplements in intestinal health. Nutrients, 2: 611-625.
8. Chen, G., H. Wang, X. Zhang and S.T. Yang, 2014. Nutraceuticals and functional foods in the management of hyperlipidemia. Crit. Rev. Food Sci. Nutr., 54: 1180-1201.
9. Wildman, R.E.C., 2006. Handbook of Nutraceuticals and Functional Foods. CRC Press, Boca Raton FL.
10. Brown, A.W., 2014. Human Nutrition Nutraceuticals. In: Encyclopedia of Meat Sciences, Dikeman, M. and C. Devine (Eds.)., 2nd Edn., Academic Press, Oxford, pp: 130-134.
11. Brown, A.C., 2016. An overview of herb and dietary supplement efficacy, safety and government regulations in the United States with suggested improvements. Part 1 of 5 series. Food Chem. Toxicol., 107: 449-471.
12. Pitkala, K.H., M.H. Suominen, J.S. Bell and T.E. Strandberg, 2016. Herbal medications and other dietary supplements. A clinical review for physicians caring for older people. Ann. Med., 48: 586-602.
13. FAO., 2002. World agriculture: Towards 2015/2030. Summary Report, Food and Agricultural Organization (FAO), Rome, Italy.
14. Oliveira, P.M., E. Zannini and E.K. Arendt, 2014. Cereal fungal infection, mycotoxins and lactic acid bacteria mediated bioprotection: From crop farming to cereal products. Food Microbiol., 37: 78-95.
15. Stark, A. and Z. Madar, 1994. Dietary Fiber. In: Functional Foods: Designer Foods, Pharmafoods, Nutraceuticals, Goldberg, I. (Ed.)., Chapman and Hall, New York, pp: 183-201.
16. Wrick, K.L., 1994. The Potential Role of Functional Foods in Medicine and Public Health. In: Functional Foods: Designer Foods, Pharmafoods, Nutraceuticals, Goldberg, I. (Ed.)., Chapman and Hall Ltd., New York, pp: 480-494.
17. Gallaher, D.D., 2000. Dietary Fiber and its Physiological Effects. In: Essentials of Functional Foods, Schmidt, M. and T.P. Labuza (Eds.)., Aspen Publishers, Inc., Gaithersburg, Maryland.
18. Angelov, A., V. Gotcheva, R. Kuncheva and T. Hristozova, 2006. Development of a new oat-based probiotic drink. Int. J. Food Microbiol., 112: 75-80.
19. Salameh, C., J. Scher, J. Petit, C. Gaiani, C. Hosri and S. Banon, 2016. Physico-chemical and rheological properties of Lebanese kishk powder, a dried fermented milk-cereal mixture. Powder Technol., 292: 307-313.
20. Kotzekidou, P. and E. Tsakalidou, 2006. Fermentation Biotechnology of Plant Based Traditional Foods of the Middle East and Mediterranean Region. In: Food Science and Technology, Pometto, A., K. Shetty, G. Paliyath and R.E. Levin (Eds.)., Marcel Dekker, New York, pp: 1795.
21. Kalui, C.M., J.M. Mathara and P.M. Kutima, 2010. Probiotic potential of spontaneously fermented cereal based foods: A review. Afr. J. Biotechnol., 9: 2490-2498.
22. Kockova, M., P. Gerekova, Z. Petrulakova, E. Hybenova, E. Sturdik and L. Valik, 2011. Evaluation of fermentation properties of lactic acid bacteria isolated from sourdough. Acta Chim. Slovaca, 4: 78-87.

23. Luana, N., C. Rossana, J.A. Curiel, P. Kaisa, G. Marco and C.G. Rizzello, 2014. Manufacture and characterization of a yogurt-like beverage made with oat flakes fermented by selected lactic acid bacteria. Int. J. Food Microbiol., 185: 17-26.
24. Peyer, L.C., E. Zannini, F. Jacob and E.K. Arendt, 2015. Growth study, metabolite development and organoleptic profile of a malt-based substrate fermented by lactic acid bacteria. J. Am. Soc. Brew. Chem., 73: 303-313.
25. AOAC., 2012. Official Methods of Analysis. 18th Edn., AOAC International, Gaithersburg, MD.
26. Tamime, A.Y., M.N.I. Barclay, R. Amarowicz and D. McNulty, 1999. Kishk-a dried fermented milk/cereal mixture. 1 Composition of gross components, carbohydrates, organic acids and fatty acids. Lait, 79: 317-330.
27. Janssen, J.W. and A.R. Helbing, 1991. Arsenazo III: An improvement of the routine calcium determination in serum. Eur. J. Clin. Chem. Clin. Biochem.: J. Forum Eur. Clin. Chem. Soc., 29: 197-201.
28. Trinder, P., 1951. A rapid method for the determination of sodium in serum. Analyst, 76: 596-599.
29. Sunderman, Jr., F.W. and F.W. Sunderman, 1958. Studies in serum electrolytes. XXII. A rapid, reliable method for serum potassium using tetraphenylboron. Am. J. Clin. Pathol., 29: 95-103.
30. Gindler, E.M. and D.A. Heth, 1971. Colorimetric Determination with Bound Calmagite of Magnesium in Human Blood Serum. In: Clinical Chemistry, American Association of Clinical Chemistry (Ed.)., Vol. 17, American Association of Clinical Chemistry, Washington, D.C., pp: 663-666.
31. Tietz, N.W., 1995. Clinical Guide to Laboratory Tests. 3rd Edn., W.B. Saunders, Philadelphia.
32. Hayakawa, R. and J. Jap, 1961. Estimation of zinc. Toxicol. Environ. Health, 8: 14-18.
33. Dreux, C., 1977. Determination of iron in serum using colorimetric methods. Ann. Biol. Clin., 35: 275-277.
34. Fiske, C.H. and Y. Subbarow, 1925. The colorimetric determination of phosphorus. J. Biol. Chem., 66: 375-400.
35. Goodwin, J.F., 1970. Quantification of serum inorganic phosphorus, phosphatase and urinary phosphate without preliminary treatment. Clin. Chem., 16: 776-780.
36. Block, R.J., E.L. Durrum and G. Zweig, 1958. Annual of Paper Chromatography and Paper Electrophoresis. 2nd Edn., Academic Press, New York, pp: 75-80.
37. APHA., 1992. Standard Methods for the Examination of Dairy Products. 16th Edn., American Public Health Association, Washington, DC., USA., ISBN-13: 9780875532080, Pages: 546.
38. Luck, H. and H. Gavorn, 1990. Quality Control in the Dairy Industry. In: Dairy Microbiology: The Microbiology of Milk Products, Robinson, R.K. (Ed.)., Vol. 2, Elsevier Science Publishers, London.
39. Wehr, H.M., J.F. Frank and American Public Health Association, 2004. Standard methods for the examination of dairy products. American Public Health Association, Washington, DC., pp: 327-404.
40. IDF., 1990. Milk and milk products-enumeration of yeasts and moulds colony count at 25° C. standard 94B. International Dairy Federation, Brussels.
41. Erkan, H., S. Celik, B. Bilgi and H. Koksel, 2006. A new approach for the utilization of barley in food products: Barley tarhana. Food Chem., 97: 12-18.
42. Hassan, E.M. and W.A. Hussein, 1987. Chemical, nutritional and sensory evaluation of different kishk mixtures [Egypt]. Egypt. J. Food Sci., Special Issue: 137-146.
43. Hair, Jr., J.F., W.C. Black, B.J. Babin and R.E. Anderson, 2010. Multivariate Data Analysis. 7th Edn., Prentice Hall, Upper Saddle River, NJ., ISBN-13: 9780138132637, Pages: 785.
44. Zare, F., C.P. Champagne, B.K. Simpson, V. Orsat and J.I. Boye, 2012. Effect of the addition of pulse ingredients to milk on acid production by probiotic and yoghurt starter cultures. LWT-Food Sci. Technol., 45: 155-160.
45. El-Aidie, S.A.M., 2005. Improving the quality and microstructure of low fat edam eheese made from buffaloe's milk. M.Sc. Thesis, Faculty of Agriculture, Cairo University, Egypt.
46. Abdel-Aal, R.I.M., 2008. Production of some special functional dairy foods. M.Sc. Thesis, Faculty of Agriculture, Ain Shams University, Egypt.
47. Tamime, A.Y., D.D. Muir, M.N.I. Barclay, M. Khaskheli and D. McNulty, 1997. Laboratory-made Kishk from wheat, oat and barley: 1. Production and comparison of chemical and nutritional composition of Burghol. Food Res. Int., 30: 311-317.
48. Damir, A.A., A.A. Salama and M.S. Mohamed, 1992. Acidity, microbial, organic and free amino acids development during fermentation of skimmed milk, Kishk. Food Chem., 43: 265-269.
49. Tamime, A.Y., M.N.I. Barclay, D. McNulty and T.P. O'Connor, 1999. Kishk-a dried fermented milk/cereal mixture. 3. Nutritional composition. Lait, 79: 435-448.
50. Tamime, A.Y., D.D. Muir, M. Khaskheli and M.N.I. Barclay, 2000. Effect of processing conditions and raw materials on the properties of Kishk 1. Compositional and microbiological qualities. LWT-Food Sci. Technol., 33: 444-451.
51. Tamime, A.Y., D.D. Muir, M.N.I. Barclay, M. Khaskheli and D. McNulty, 1997. Laboratory-made Kishk from wheat, oat and barley: 2. Compositional quality and sensory properties. Food Res. Int., 30: 319-326.